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The Spatial-Temporal Reasoning States of Children Who Play a Musical Instrument, Regarding the Mathematics Lesson: Teachers' Views

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The aim of this study is to try to investigate the spatial-temporal reasoning states of primary school children between the ages 8 and 11 who play an instrument, regarding mathematics lessons from the teachers' views. This current study is both qualitative and quantitative in nature. In other words, the mixed research method was used in the study. Regarding the teachers' views, the memories of these students in mathematics and music lessons were found to be "excellent". Also, their effective use of numbers and visual intelligence in music lessons was found to be "excellent". As a result, it was seen that there was a significant but weak correlation between the spatial-temporal reasoning states of children who played an instrument, regarding the mathematics lesson, and the abilities of playing an instrument.

Keywords: mathematics, music, reasoning, spatial, temporal

INTRODUCTION

While mathematics is an element of science, music is an art. These two disciplines have been compared and associated with each other since ancient times (Bora, 2002). The research carried out so far has shown that music education develops brain activities and has an impact on mathematics performance (Hallam, 2010). Researchers think that abstract mathematics cannot be done with young children; however, they believe that making them listen to music, which would be their favourite, would provide them with higher brain functions (Crncec, Wilson & Prior, 2006). Shaw (2000) pointed out that music education, especially if started with pre-

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schoolers, affects the child's spatial-temporal reasoning and this, in return, can affect his/her mathematics performance positively in the future.

In addition spatio-reasoning can be associated with improvisation. This ability can be seen in the early stages of childhood and is developed during their music studies. Johnson-Laird (1991, 2002) studied the creativity process and he argues that improvisation can be made easier for experienced people; however, if early stage children have the ability for improvisation, it can being as a simple process for them by using their short-term memory.

Crncec, Wilson & Prior (2006) have demonstrated that there is no evidence claiming that people with high intelligence have good musical performance; nonetheless, people with good musical performance often have good mathematical intelligence and mathematical thinking ability too. Children with good spatial-temporal reasoning can display mathematical thinking ability in their early childhood and are capable of doing puzzles, playing with blocks, drawing pictures and playing an instrument. Also, these children with good spatial-temporal reasoning could be good musicians, architects, carpenters, sculptors, organizers or painters who can draw pictures of three dimensional objects.

One of the significant researchers in the literature, Beer (1998), expressed which main elements of music have a relationship with mathematics. He claimed that the elements that are claimed to have a relationship with mathematics are notes, tones, scales and harmony. Beer (1998) pointed out that there are certain mathematical concepts in music, which are also considered to be an important subject; some of these are rhythm, melody and music notation.

State of the literature

- Playing an instrument activates the temporal dimension, which is also known as the sequential processing function, located in the left hemisphere of the brain.
- Playing an instrument plays an efficient role, particularly for the positive impact of performance over mathematics.
- Music education is not just associated with mathematics at young ages, it is also known that music education promotes language learning, reading and writing skills and playing an instrument

Contribution of this paper to the literature

- The main contribution of this paper to the literature is to try to point out the spatial-temporal reasoning states of primary school children between the ages 8 and 11 who play an instrument, regarding mathematics lessons from the teachers' views.
- Those children who play instruments can use numbers effectively in mathematics lessons and have a "very good" memory.
- This paper provides a significant contribution to the literature on the correlation between the musical instrument playing skills of students and spatial-temporal reasoning states towards mathematics for students who play an instrument.

Another important factor of music and mathematics association is "The Mozart Effect" defined as the ability of a Mozart sonata to improve the listener's mathematical and reasoning abilities (Marsh, 1999). There have been numerous research papers and experiments done by prominent researchers so far about this (Kliewer, 1999; Shaw, 2000). Generally, it is known that "The Mozart Effect" is very effective on children and, moreover, the literature is rich with research and experiments supporting this. For instance, "The Mozart Effect" that is used as an example for the cognitive skills of pre-school children, is also measured in a study to find out the effect of spatial skills and the results showed that there was a 30% increase in spatial perception tests of children who were exposed to listen to works of Mozart for only 10 minutes. After that successful increase in spatial perception tests, the same researchers searched whether there were similar effects using modern music; however, the results demonstrated that there was no effect found (Rauscher, et al., 1997).

There is another important point to be mentioned here that the rhythm studies that are particularly implemented in pre-school education are associated with mathematics and musical experiences, also play a significant role in gaining spatial relations and shape concepts at young ages (Rauscher, et al, 1997). Along with this,

it is also stressed that mathematical thinking and mathematical relations lie at the basis of music. Besides this, music education is not just associated with mathematics at young ages, it is also known that music education promotes language learning, reading and writing skills and playing an instrument (Rauscher, et al., 1997; Bilhartz, et al., 1997; Dikici, 2002; Hallam, 2010; Öziskender & Gudek, 2013).

The approach adopted by the elementary mathematics curriculum started to be implemented in Northern Cyprus in 2006, revised in 2011, involved mathematical thinking, problem solving, building associations and using mathematics as a language of communication and modelling skills. These are known as the basic elements of learning and doing mathematics processes (MEB, 2014). In the curriculum, it is stressed that a student is required to have certain qualities, like problem solving, reasoning, communication (abstract mathematics, setting up a bridge and etc.), guessing strategies and building associations (in daily life, other lessons, etc.).

As it can clearly be seen, mathematical thinking is one of the skills that is considered necessary to teach to students in mathematics teaching. The importance of teaching this skill is also underlined by one of the most prominent institutions, called the National Council of Teachers of Mathematics (NCTM), which provides mathematics education. In Principles and Standards that was published by NCTM (2000: 4), it was defined that the need for understanding and acknowledging mathematics in daily life was gradually increasing and that there was more need for problem solving and mathematical thinking in a number of professional fields, from health to graphic designing.

Akkaş (1993) believed that children begin showing their reactions towards music before their birth and it is possible to observe children's interests and abilities in music after they are born. It is pointed out that children who receive music education are not only successful in musical fields, but they are also successful in other fields of education and are given new points of view with the music education that they receive. It is also stressed that practising music increases the feeling of success, provides ways of being proud of oneself, as well as promoting one's trust in himself/herself (Lazdauskas, 1996).

Today the grade exams of the Associated Board of the Royal School of Music (ABRSM) are frequently held in the Northern Cyprus, as they are held all over of the world. Harvey (1994: 8) stated that the grade exams are worldwidely popular and this popularity is because people want to increase in their musical ability therefore, the number of people taking these grade exams every year has increased and has now reached 350.000 per year. However, the format of these exams does not change. Hallam (1998), defined the exam format as: 3 repertory works from the grade book editions that change in certain years and for technical studies there are scales and arpeggios, sight-reading and aural works (Grade exams are from 1 to 8, and a student can finish up to grade 5 throughout primary education in general).

Although there is significant research in the literature pointing out that there are important advantages of the grade music exams, some other prominent researchers have not been so positive about them. Hallam (2002) believed that passing grade exams with a high score increases children's motivation. Likewise, Taylor (1982) claimed that grade exams give children a chance to develop their music abilities. On the other hand, Davidson and Scutt (1999) clearly stated that a child could lose his/her concentration, feel disappointed and even could even make the decision not to continue doing music if they failed a grade exam. It is also stated that children would only improve in the subjects that are included in the grade exam's curriculum. Thus, any other subject of music education, which remains outside the grade exams curriculum, would not be offered to the students.

Playing an instrument activates the temporal dimension, which is also known as the sequential processing function, located in the left hemisphere of the brain and it

plays an efficient role, particularly for the positive impact of performance over mathematics. The concept of spatial is about to what extend the shape and appearance of a three dimensional object can be imagined. Here, it means to be able to envisage and distinguish the details without seeing the object itself (Talu, 1999; Arnold & Fonseca, 2004). Reasoning on its own, is not sufficient, it has to function sequentially. For example, a student could understand a question by reasoning, but may, nonetheless, have some problems while solving it. Therefore, it is important for this to continue sequentially (understanding the question, solving it correctly and finding the correct answer) (Tekin, 2007).

The research carried out in the literature so far has shown that students demonstrate more success in the problems which require them to find the answer by directly applying it and which do not require any interpreting or reasoning. Music and mathematics are closely connected with each other and music as a branch has a positive impact on mathematics. Reasoning is an important factor for solving a problem in mathematics, but being time wise and sequential is more important for this (Önal, 2012).

Hetland (2000a) carried out several meta-analysis studies to examine the impact of music lessons over spatial-temporal reasoning and other skills. The works of Hetland consisted of nine unpublished and 15 published analyses. These studies were done on 701 children, who attended music lessons from four months to two years and were aged between three and 12 years. Therefore, one could conclude that in his published works, Hetland underlined that children who continued to have music lessons improved their spatial-temporal reasoning skills.

It is acknowledged that enabling students to gain mathematical thinking skills in mathematics teaching and, even in all disciplines, is very important, although it may not be too easy to implement. It is well known that the socio-economic status level influences success. One of the requirements to be fulfilled in order to be an information society in an information age, in today's process of globalization, in the global competitive environment, in less developed and developed countries, is to receive a musical education or to play an instrument. There is no doubt that this situation is more popular in developed countries than developing countries, where playing an instrument and receiving musical education are considered important (Önür, 2013).

There is a lot of research about academic success, regarding mathematics and music, which are the two crucial elements of human life (Bora, 2002; Dikici, 2002; Hallam, 2010). In particular, in developed countries, the correlation between spatial-temporal reasoning towards mathematics lessons of primary school students preparing for music grade exams is quite significant. The presence of this correlation may increase the importance of grade exams and may develop spatial-temporal reasoning of students better in mathematics lessons in the primary school period. This is believed to be reflected in their academic success (Crncec, Wilson, & Prior, 2006). However, there has been no research carried out about the spatial-temporal reasoning of children who play a musical instrument in the mathematics lesson. Therefore, this study aims to identify the views of both classroom (mathematics) and music teachers regarding the spatial-temporal reasoning of children in the maths lesson, who play an instrument and the correlation between them.

METHOD

Research design

This current study is both qualitative and quantitative in nature. In other words, the mix d research method was used in the study. In this way, all the strong aspects of qualitative e and quantitative data were reflected in the research findings

(Büyüköztürk, et. al., 2011). In the qualitative research method, for teachers' views about the participant students, semi-structured interview questions were used. In addition, how and why students chose their musical instrument was discussed (Figure 1). In the quantitative method, however, two different scales were developed. The first consisted of seven items and recorded the views of music teachers about the musical instrument playing skills of students (MIPS) and the second one consisted of eleven items and recorded the views of classroom teachers about the spatial-temporal reasoning states (STRS) of children in the maths lesson, who played an instrument. Thus, the data obtained from these two scales was blended with the qualitative data. The study was carried out in spring semester of the 2014-2015 academic years.

Study group

To fit the purpose of the current study, only the students who could play at least one instrument and had entered grade exams before, were included in the research. The study group was formed from classroom and music teachers who taught 120 students in three state and three private primary schools located in Nicosia, Northern Cyprus. These 120 primary school students (aged between 6 and 11) were the ones getting ready for grade exams. Questionnaires in two parts were given to music and classroom teachers who taught these students. Of these students, 53% were at grade 1 level, 10% of them were at grade 2, 20% of them were at grade 3, 13% of them were at grade 4 and 4% of them were at grade 5 level. These percentages are given in Table 1.

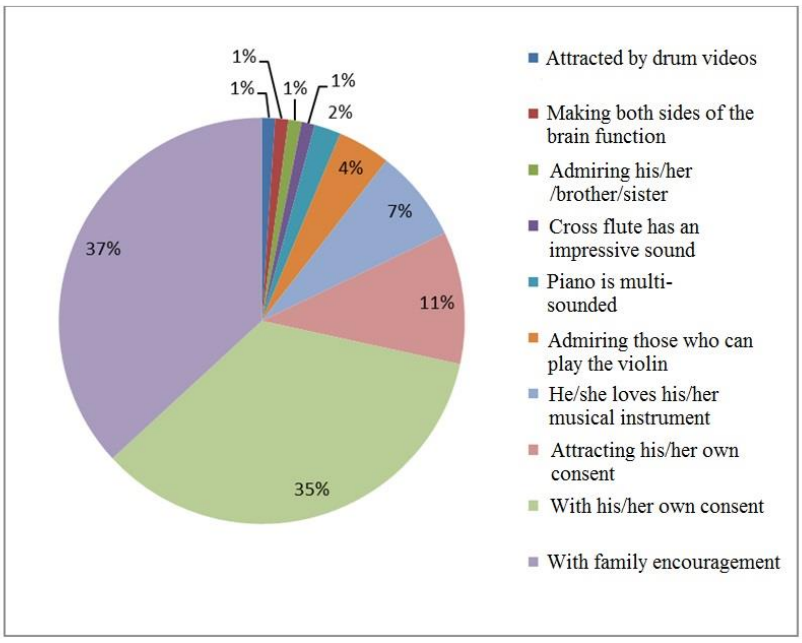

Figure 1. Why students choose their musical instrument

Table 1. Grade levels of students who were included in the research

Grades	Percentages (%)
Grade 1	53
Grade 2	10
Grade 3	20
Grade 4	13
Grade 5	4

Data collection instrument and application

For the purpose of the study, there was a need for two different measuring instruments to be used, in order to determine the views of both the class teacher and the music teacher to identify STRS of every primary school student in the maths lesson who also played an instrument. Therefore, with the aim of forming the items of the scale, 20 classroom teachers serving in state and private schools of the Ministry of Education were asked to write a composition regarding their emotions, views and attitudes of students' reasoning in the mathematics lesson and music teachers were also asked to write a composition regarding students' instrument playing and being successful in grades. Also, the relevant literature was reviewed before forming items towards STRS in the mathematics lesson and it was decided which item was appropriate for mathematical performance, and temporal-spatial reasoning (Table 7). Items focussing on getting prepared for students' MIPS, the grade exams of the ABRSM, were also taken into consideration (Taylor, 1982). Through the content analysis carried out for the compositions written and, as a result of the literature review, eight items were written for the views of the music teachers on students' MIPS and twelve items were written for the views of mathematics teachers on students' STRS in the mathematics lesson. Altogether, twenty view items were written. For content and face validity of the scale, the views of two primary school classroom teachers and six university lecturers of the departments of mathematics education and curriculum and instruction were taken. As the result of the experts' examination, one item was taken out from the mathematics scale. Items were also analysed by a language expert. Thus, according to the experts' views, necessary corrections were done and the draft form was developed into the final form of the two scales and these were developed for determining both the STRS and MIPS of students in the mathematics lesson that also played a musical instrument.

It was recommended that the number of items should be two times more considering the factor analysis of the group size and item analysis (Kline, 2014). For the validity and reliability analysis of the testing form as a data collection instrument, it was applied to 50 teachers as a pre-testing group of 50 students. In the research, for reactions given for the items that were 20 in total on both scales, a 5-point Likert-type scale was preferred. The participants were asked to classify each item into one of the five categories on the scales as: very weak, weak, average, good, and very good. In order to make a general interpretation for the mean values of: 1-1.80 = very weak, 1.81-2.60 = weak, 2.61-3.40 = average, 3.41-4.20 = good, 4.21-5 = very good, were taken according to the students' statement. For obtaining the total points for each participant, the most positive category was given five points and the most negative category was given one point and the answers gathered were scored between one and five points. In choosing items for the scale, it was decided that the value of the total item correlation coefficient would be over 30. Cronbach's Alpha technique was used for the validity of the scales. In general, reliabilities of less than 0.60 were considered poor, those between 0.60 and 0.70 were acceptable, and those over 0.80 were good. A reliable instrument is one that gives consistent results (Fraenkel & Wallen, 2006). The values for STRS and MIPS obtained were 0.98 and 0.91, respectively, and this indicates that both of the scales were very reliable. As the result of pre-testing, for the views of the music teachers towards MIPS, seven items were found to be clear. Likewise, for the views of the classroom teachers of the same students towards STRS, eleven items were found to be clear. In addition, nine questions of the semi-structured interview forms, which were confirmed by the experts, were formed in order to identify the musical and mathematical states of each student. Before the scales were taken their final form, after being implemented to the pre-testing group (classroom teachers), the advantages and limitations of

spatial-temporal reasoning in the mathematics lesson were well explained. The researchers distributed the questionnaires to the teachers and collected them at the end of the interviews.

Data analysis

The data collected through questionnaires from state and private primary schools was analysed by the researchers themselves using the SPSS 20.0 programme. In the data analysis, in order to identify the views of classroom and music teachers who took part in the sampling, percentages, means, factors and total variance analysis about each sub problem were tabulated and the necessary evaluations were carried out.

Factor analysis is seen as the most effective technique of all by many researchers (Kahn, 2006). To test whether the data and the number of samples were appropriate for the factor analysis, Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity (BTS) were carried out. For the data to be appropriate for the factor analysis the KMO should be over 60 and the Bartlett's test result should be statistically significant (Büyüköztürk et. al., 2011). The KMO value for the items of STRS was found to be 0.947, whereas it was found to be 0.901 for the items of MIPS. The BTS result indicated that both of the STRS and MIPS had $p = 0.000 < 0.05$, which meant that the matrix where there were correlations between items was different from the unit matrix where there were no relations. Also, the scree plot graphics showed that a sharp decrease demonstrated that both of the scales had single-factor structures and no rotation process was performed at the end of this. For the STRS, the total variance that was explained by a single factor was 85.15%, however, this percentage was 70.18% for the MIPS instrument. On the other hand, close examination of the results of the Kolmogorov-Smirnov test was carried out for STRS and for MIPS instruments, it was seen that they were not normally distributed ($p<0.05$). Therefore, in order to specify the correlation between the two, Spearman rho (rs) was used. Generally, Spearman correlation coefficients can range between a negative one (-1.00) and a positive one (+1.00). Positive coefficients indicate direct relationships, while negative coefficients indicate inverse relationships. The correlation value is weak if it is between 0-0.30, average if it is between 0.30-0.70 and high if it is between 0.70-1 (Büyüköztürk, et. al., 2011).

FINDINGS AND INTERPRETATIONS

At the end of the interviews, which formed the qualitative dimension of the research, there were questions for students on how many years they had received education in playing a musical instrument, at what age they started which musical instrument they played. The aim of the classification in this study is to state that the students have the background of music and they have approximately 2 to 3 years music education.

As Table 2 demonstrates, 60% of students had been taking musical education between 1 and 2 years, 32% of them between 3 and 4 years and 8% of them between 5 and 6 years. One percent of students started to receive their education in

Table 2. Students' who were included in the research, their ages, music education years and musical instruments

Years	Education (Percentages %)	Ages	Percentages (%)	Instruments	Percentages (%)
1-2	60	3	1	Piano	51
3-4	32	4	4	Violin	16
5-6	8	5	6	Flute	16
		6	16	Guitar	13
		7^{+}	73	Drums	4

playing instruments at age 3, 4% of them at age 4, 6% of them at age 5 and 16% of them at age 6. Also, 51% of the students included in the research played the piano, 13% of them played the guitar, 16% of them played the violin, 4% of them played the drums and 16% of them played the flute.

As Table 3 demonstrates, the views of music teachers about students playing instruments indicate that 24% of the students were skilled and successful, 19% of them had a very good rhythm and melody memory. Also, it was specified that 10% of them were diligent, curious, and successful and studied carefully. The rest of the views are given in Table 3.

In Table 4, the views of classroom teachers show that 44% of the students who played instruments were disciplined and successful in the mathematics lesson but 10% of them, on the other hand, would be more successful if they studied regularly and increased their attention. For rest of them, it was stated that they were sociable, intelligent and diligent but needed to be encouraged. Some other teachers' views indicated that 3% of them were weak, needed help or their success was not at the required level.

Results showed that 93% of the participants did like playing their musical instruments, however, 7% of them did not and the reason for this was that the students did not want to study as can be seen in Table 5. It should not be ignored that, in the teaching process, students are expected to be diligent and hard-working and this is considered to be a very important factor.

Another finding obtained showed us that 7% of the students did not like the mathematics lesson very much, 30% of them liked it at an average level and 63% of

Table 3. The views of music teachers about the students playing an instrument

Percentage	Views
19	Has a very good rhythm and melody memory
24	Is a skilled and successful student
10	Studies carefully
7	Should increase sight reading lessons
2	Enjoys studying
2	Finds playing the violin difficult
7	Is skilled and hardworking
7	Is successful and hardworking
5	Needs to study more
10	Is curious, diligent and successful
2	Has a very good rhythm sensation
2	Plays the piano willingly and enthusiastically
2	Loves playing the piano

Table 4 . The views of classroom teachers about the students who played an instrument

Percentage	Views
10	Will be more successful if he/she increases his/her attention
44	Is a disciplined and successful student
10	His/her success will increase if he/she studies regularly
3	He/she is a sociable student
3	Is intelligent but needs encouragement
1	Grasps topics well
1	Is very good at solving problems
1	Is a quiet student
3	Is a diligent student
1	Should revise regularly
1	Is successful, hardworking and curious
1	Is better at visuals
1	Needs special attention
1	Studies regularly
1	Gets bored quickly
1	His/her success is not at the required level
3	Is weak and needs help

Table 5. The views of students who do not like playing musical instruments

Number	Reason
1	Gets bored
1	Finds work difficult
1	Finds playing the violin difficult
4	Does not want to study

Table 6. The item means of the scale of STRS

		Mean	Rate
M1	How effective can student X use the numbers? (Mathematics Performance)	4.22	Very Good
M2	To what extent can student X establish a link between concepts? (Reasoning)	4.05	Good
M3	To what extent can student X distinguish patterns? (Reasoning)	4.01	Good
M4	To what extent can student X make a classification? (Reasoning)	4.00	Good
M5	How good is student X's memory in the mathematics lesson? (Temporal)	4.21	Very Good
M6	How does student X perceive geometry? (Spatial)	4.16	Good
M7	How good is student X's ability to see details and envision an object without seeing it? (Spatial)	4.00	Good
M8	How good is student X at comprehending a question - solving it correctly- finding the correct answer? (Temporal)	4.05	Good
M9	How does student X use sequential processing function while solving a problem? (Temporal)	4.02	Good
M10	How well does student X use mathematics in other lessons? (Reasoning)	4.06	Good
M11	How successful is student X at directly solving problems? (Temporal)	4.07	Good

them loved it very much. However, it is very well known that every student cannot like mathematics lessons; moreover, the classroom teacher plays a big role in making students like mathematics. Mathematics that is one of the most lugubrious lessons to be loved very much by the majority of the students.

The correlation level of teachers' views between the MIPS and STRS

For a determination of the correlation level of teachers' views between the MIPS and STRS, Spearman's Rho test was carried out and the Spearman's Rho correlation coefficient was found to be 0.21 (p<0.01). The result shows that there is a significant weak correlation between the MIPS and STRS towards mathematics for students who play an instrument.

Table 6 shows 11 basic items about students' spatial-temporal reasoning states in maths lessons. From our observations, the spatial-temporal reasoning states in items 11 is essential for the children's perception of mathematics lessons and is in accordance with expert analysis of spatial and temporal reasoning theories which have been compiled. It can be seen in Table 6 that, those children who play instruments can use numbers effectively in mathematics lessons and have a "very good" memory.

In the rest of the items, which are: to what extent can the student establish a link between concepts?, to what extent can the student make a classification?, how the student perceives geometry, how good is the student's ability is to see details and envision an object without seeing it?, how good is the student at comprehending question solving by correctly finding the answer?, how the student uses sequential processing functions while solving a problem, how well the student uses mathematics in other lessons and how successful the student is at problems that require solving directly at the rate of "good".

Finally, when Table 7 is taken into consideration, it can be said that children who play musical instruments are all "good" at playing a musical instrument from ear, counting correctly while harmonising the rhythm, classifying similar rhythm structures while reading musical notes, recognising the melody heard, reading musical notes by reasoning. Also, the rates of visual intelligence and memory in

Table 7. The item means of the scale of MIPS

		Mean	Rate
M12	To what extent does X student play a musical instrument from ear?	3.66	Good
M13	To what extent X student is good at harmonising the rhythm while counting correctly?	3.91	Good
M14	How well does X student classify similar rhythm structures while reading musical notes?	3.81	Good
M15	How good is X student at recognizing a melody he/she has heard?	3.83	Good
M16	To what extent does X student read a musical note by reasoning?	3.83	Good
M17	How is X student's visual intelligence in a music lesson?	4.06	Good
M18	How good is X student's memory in a music lesson?	4.02	Good
M19	To what extent does X student read notes while playing a musical instrument?	3.84	Good

music lessons and reading musical notes while playing a musical instrument are "good".

CONCLUSION AND DISCUSSION

Despite the current study being limited to the views of teachers and students, this study only examined the views of teachers. According to Cerit (2008), the views of teachers are important as teachers are one of the most important components of education. Cerit (2008) also added that teachers play an efficient role carrying out effective activities for education. Therefore, in the direction of teachers' views have been analysed and from the findings it is clear that children who play musical instruments are affected positively in terms of their spatial-temporal reasoning. The findings of our study support the findings of Hetland (2000b) and Shaw (2000). In addition, it is in accordance with the results claiming that if a music performance of a student is good, his/her mathematics performance is also good. Furthermore, those children who play instruments can use numbers effectively in mathematics lessons and have a "very good" memory.

It is well known that parents have a crucial function in a child's education. In the light of the findings, 35% of the children were directed towards musical education (playing a musical instrument) with family encouragement (Figure 1) and 93% of the children loved the musical instrument they play and, apparently, this indicates that parents are an important factor in directing a child and also this has an important place in education. A significant weak correlation was found between the musical instrument playing skills of students and spatial-temporal reasoning states towards mathematics for students who play an instrument. The correlation between musical ability and mathematical ability could add new dimensions in education. Many research papers carried out regarding mathematics all over the world have shown that mathematics education is not sufficient and there is a need for new approaches.

The findings showed that the majority of the students chose their musical instrument with family encouragement and this is followed by a voluntary choice of students. But, Bora (2002) claimed that students' voluntarily choice of musical instruments increase their performance in music and thus, this could support their performance in maths in a positive way.

Music could be used as a very effective means of education, in particular, with preschool children. The horizons of children could improve dramatically if the basics of mathematics and music education are provided "correctly" in this period. Both listening to music and playing musical instruments provides a positive impact on the cognitive activities of people, not only in the preschool period, but also in subsequent periods and it is worth saying that this has been a subject of much research and should not be underestimated.

Children with advanced cognitive skills are better at perceiving music and improving it. If it is thought that these two disciplines are related in terms of ability, it should not be forgotten that children with high musicality have much more advanced mental capacities and the importance of spatial-temporal reasoning states. Thus, it is necessary to make more researches about the area of spatial-temporal reasoning.

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